Memorandum

Environment and Resources
55 Wheeler Street, Cambridge, MA ◆ Tel: 617 492-7100 ◆ www.abtassociates.com

Abt Associates Inc.

Date	August 10, 2010
To	Ashley Allen and Jason Berner, U.S. Environmental Protection Agency (EPA)
From	Lauren Parker, Viktoria Zoltay, and Elena Besedin, Abt Associates
Subject	Additional Mini Literature Reviews for the Post-Construction and Development Stormwater Rulemaking

1. Introduction

Abt Associates conducted additional literature reviews to identify, acquire and review literature in support of the environmental assessment analyses for the post-construction rulemaking. These additional literature reviews focused on four topics: the use of (1) fertilizers and (2) pesticides within the Chesapeake Bay (CB) watershed and their impacts on water quality, and the extent of stormwater runoff from (3) linear development and (4) unpaved roads and its impact on the surface waters of the United States (US). We reviewed both for peer-reviewed and grey literature on these topics.

For fertilizers and pesticides, we sought data and information specifically for the CB. We found that a large portion of the existing literature on fertilizers and pesticides are related to agricultural applications and information specifically related to the urban use of fertilizers and pesticides is less available. We found limited information and data on the impact and extent of stormwater runoff from linear development and unpaved roads.

2. Impact and Use of Urban Fertilizers in the CB Watershed

2.1. Impact

Fertilizers contain nitrogen (N) and phosphorus (P) which are well documented contributors to the eutrophication, or over-enrichment, of surface waters of the US including the CB (Fuhrer et al. 1999; Boesch et al. 2001; Law et al. 2004; Kemp et al. 2005; Fisher et al. 2006). Scientists have documented that excessive nutrients cause eutrophication which leads to hypoxia, loss of submerged vegetation leading to increased turbidity, alterations of food webs, and harmful algal blooms (Boesch et al. 2001). The effects of increased nutrient loadings are also evident in tributary streams that feed the CB (Fisher et al. 2006). A modeling study of two tributaries by Fisher et al. (2006) suggested that current N and P inputs are 4-20 times greater than during pre-development conditions. Specific studies of the fate and transport of nutrients have also been conducted (Lindsey et al. 2003; Ator et al. 2004).While the impact of excessive nutrient loadings in the CB is well studied and documented, most studies do not quantify the contribution of nutrients from various point and nonpoint sources and/or focus on agricultural sources when providing recommendations for nutrient reductions. For example, the fate and transport studies by Ator et al. (2004) and Lindsey et al. (2003) were conducted on the Delaware-Maryland-Virginia Peninsula which has a predominantly agricultural land use (48% agriculture, 7% urban). Boesch et al. (2001) focused exclusively on recommendations for reducing nutrient loads from agricultural land uses but lists "horticultural fertilization" as one of several impacts from sprawling suburban development which is discussed under the heading of emerging issues. Boesch et al. (2001) point out that nutrient loading reductions must come agricultural sources which are the largest contributors but to maintain reduced loading levels, loadings from new development will have to be limited.

Two references specifically estimated the percent nutrient contribution by various sources to the CB. Megnien et al. (1995, as cited in Boesch, 2001) estimated that urban and suburban lands contributed 9 percent of N and 8 percent of P loadings to the CB. More recently, based on the CB Watershed Model (CBWM), runoff from developed land (urban and suburban) was estimated to contribute approximately 11% of the total nitrogen and 31% of the total phosphorus loading to the CB in 2008 (Chesapeake Bay Program Office (CBPO) 2009). In addition, despite significant efforts to reduce nutrient loadings throughout the CB watershed, developed lands and septic systems were the only source categories that increased from 1985 to 2008 while all others decreased (CBPO 2009).Therefore, while no studies were located that directly quantified the contribution of urban fertilizer use and documented its impact on the CB, data and documentation does exist that provide a link between urban fertilizer use and the impaired state of the CB.

In addition, there is indirect evidence that the impact of urban fertilizers on the CB's water quality is widely accepted. For example, there are several initiatives targeted at reducing nutrient inputs from lawns such as the "Save the Crabcakes" campaign that included brochures, educational media programs, and slogans (Chesapeake Bay Social Marketing Initiative 2005).There are also regulatory measures to limit fertilizer use on lawns such as the City of Annapolis' 2009 ordinance limiting the use and sale of fertilizers. This ordinance was superseded by Maryland (MD) state regulations that same year and restricted the use and sale of fertilizer to low-phosphorus fertilizer (Maryland Annotated Code (MDAC) 2009). The MDAC also specified that fertilizer manufacturers are required to reduce the amount of available phosphoric acid resulting from application of their products to 50% of 2006 levels. Manufacturers that did not sell or distribute fertilizer prior to April 1, 2010 may not exceed an average of 1.5% available phosphoric acid in their products. In addition, all manufacturers are required to report the total pounds of phosphorus sold within MD (MDAC 2009).

Two papers reporting results from surveys on urban fertilizer use also made statements attributing partial responsibility for the impairment of the CB to urban fertilizers (Law et al. 2004; Swann, 1999). In a survey of lawn fertilizer application rates, Law et al. (2004) stated that ongoing residential fertilizer practices, coupled with historic pollution, contribute to the non-point source pollution in the CB. Similarly, in a survey to determine the effectiveness of nutrient educational programs, Swann (1999) acknowledged that improper lawn care practices including fertilizer application are partly responsible for nutrient inputs to the CB.

2.2. Application rates and usage

According to the USGS, the Chesapeake Bay watershed is one of the most populous coastal estuaries in the United States (Claggelt 2007). Between 1990 and 2000, population in the Bay watershed increased by 8% while impervious cover increased by approximately 40% (Claggelt 2007). Therefore, the rate of increase in urban land area is significantly out-pacing population growth. Turf grass associated with urban development (e.g., residential laws and recreational areas where grass is cultivated and maintained) constitutes approximately 9.4 percent of the land area in the CB (Schueler 2010). Increase in urban land and the associated turf grass is reflected in the steady increase of non-farm fertilizer use in Maryland from 13% of total fertilizer use in 1990, to 37% in 1999, and 45% in 2001 (Montgomery County 2003). In the District of Columbia primary metropolitan statistical area, lawn fertilizers contribute approximately 4.7 million pounds of N and 560,000 lbs of P to the CB each year (CBSMI 2005).

The University of Maryland Cooperative Extension provides recommendations for lawn care which includes annual fertilizer application rates that vary depending on the type of vegetation and plant maturity (Gill et al. 2001). An application rate of 1 lb N/1,000 square feet per year (sq ft/yr) for laws and 0 to 4 lb N/1,000 sq ft/yr for plants depending on their maturity (Gill et al. 2001; Ricigliano 2004). Actual fertilizer application rates are affected by the level of turf maintenance desired by the owner, whether application is done by the owner or a landscaping company, and the type of lawn (e.g., golf course, residential lawn). Wible (2010, as cited in USEPA 2010b) estimates an annual rate of 1 to 2 lbs N/1,000 sq ft for low-input turf and 3 to 5 lbs N/1,000 sq ft for high-input turf. More specific application rates were estimated by Schueler and Holland (2000 as cited in USEPA 2010b) and are detailed in the *Table 1* below.

Table 1. Fertilizer application rates (lbs/1000 sq ft/yr) in Maryland (Schueler and Holland 2000 as cited in EPA 2010)

Chemical	Golf Fairway	Greens	Home Lawn (do-it-yourself)	Home Lawn (lawn care services)
N	3.5	4.9	1.0-6.0	4.5-5.9
P	2.0	1.0	0.4	no data

Based on a survey conducted in two watersheds in Baltimore County, MD, Law et al (2004) found that nitrogen inputs varied spatially, based on socioeconomic factors and soil characteristics, and temporally, depending on the season. The authors found that there is a statistically significant relationship between higher application rates and more recently developed homes. They hypothesized that newer construction results in poor soil quality and consequently lawns require higher fertilizer application rates. The authors also estimated that lawn fertilizer application accounts for 53% of the total nitrogen input to the Glyndon watershed. They estimated a mean fertilizer application rate of 1.99 lbs N/ 1,000 sq ft/yr with a standard deviation of 1.81 lbs N/ 1,000 sq ft/yr. A summary of turf application rates from 12 other studies around the US was included in this study. With the exception of one outlier study[1], estimates ranged from 0.49 to 11.06 lbs N/1,000 sq ft/yr.

Approximately 70% of the total turf area in the CB watershed is residential lawns with half of these lawns maintained as high-input turf (Schueler 2010). Public turf (e.g. parks, median strips, golf courses, cemeteries) accounts for the remaining fraction with one-third maintained as high-input turf. Using these estimates, the EPA (2010a) calculated that the total N *applied* to turf areas in the watershed is approximately 389 million lbs N/yr. Schueler (2010) estimated the nitrogen fertilization rate of turf areas at 215 million lbs N/yr in the CB watershed.

For the conterminous US, Ruddy et al (2006) estimated that non-farm fertilizer use in 1997 accounted for 537 million lbs of N and 88 million lbs of P. Furthermore, a survey found that 35% of US households over-fertilize their lawns (Swann 1999).

2.3. Data sources

The Maryland Department of Agriculture (MDA) published a registry of fertilizer manufacturers, their products, and the N, P, and potassium percentages for each product but without specifics about whether the application of these fertilizers are in agricultural or urban setting (MDA 2010). We requested and are waiting for Maryland's Annual Fertilizer Tonnage Reports from the MDA which includes statistics on total agricultural and non-farm use trends between 1990 and 2004 (Montgomery County 2003). The US Geological Survey developed county-level estimates of non-farm fertilizer use expressed as N and P inputs for 1987 through 2001 (Ruddy 2006). From this data they developed a relationship between population density and non-farm fertilizer sales for 1992.

The CBWM includes estimates of the rate of N and P loadings from pervious urban land use to the CB expressed in pounds per acre per year (lb/ac/yr). These values were based on total urban fertilizer sales with the CB watershed (Claggelt 2010) but the year of this data is not known. The loadings are provided both as "edge-of-stream" and as "delivered" to the CB incorporating attenuation factors. This data was used in the model and values are available for monthly estimates of nitrogen and phosphorus fertilizer loads to urban pervious areas. These values are provided by land use type, including high and low intensity developed pervious surfaces, for the years 1985, 1987, 1992, 1997, 2002 and 2005 (USEPA 2010a). The CBWM also includes estimates of best management practice (BMP) implementation levels in 2008 and the number of acres of urban land that remains untreated by BMPs. Therefore, the CBWM may be the most comprehensive and consistent source of data for analyzing the effects of stormwater BMPs on reducing nutrient inputs from urban fertilizer use. Depending on the type of analysis that may be conducted for the stormwater rulemaking, it may be important determine the year of the fertilizer use data used in the CBWM and potentially update the data.

[1] The outlier estimated a range of 0 to 40.65 lbs N/1,000 sq ft/yr.

3. Impact and Use of Urban Pesticides in the Chesapeake Bay Watershed

3.1. Impact

Pesticides are synthetic organic chemicals used to control weeds, insects, fungi, and other pests in agricultural, commercial, industrial, transportation, public-health, and other applications (Denver and Ator 2007). The impact of pesticides on human and ecosystem health have been documented in the US as well as the CB (Ferrari et al. 1997; Fuhrer et al. 1999; MPN 2009). Exposure to individual pesticides has been studied and linked to numerous adverse health outcomes as summarized in *Table 2* based on a literature review by the MPN (2009).

Table 2. Possible Human and Ecosystem Health Effects Associated with Pesticide Use (as cited in MPN 2009)

Health Effects	Study
Human	
Glyphosate exposure can double the risk of developing non-Hodgkin lymphoma	Eriksson et al. 1998
Seven-fold increase of risk of childhood leukemia associated with household and garden pesticide use	Lowengart et al 1987
Increased rates of childhood leukemia, brain cancer and soft-tissue sarcoma linked to household pesticide use	Leiss et al. 1995; Gold et al. 1979; Lowengart et al. 1995; Reeves 1982; Davis et al. 1993; Buckley et al.1994
Carcinogenic implications of pesticides	Zahm, Hoar and Ward, 1998
Obesity and Type 2 diabetes	Lassiter et al. 2008
Increased risk of Parkinson's Disease, sometimes as much as 70%	Chou et al. 2009, Ascherio et al. 2006
Immune system	Porter et al. 1999
Endocrine system including birth defects including altered genitalia, language and mathematically skills, and other subtle biological responses; induce abortions and resorption of fetuses	Porter et al. 1999, Cavieres et al. 2002, Hayes et al. 2006
Proximity of mother to pesticide-treated fields during pregnancy increases risk of childhood autism by 6-fold	Roberts et al. 2007
Cardiovascular and reproductive system disorders; eye, liver, kidney or spleen; anemia; increased risk of cancer; blood-related problems	US EPA 2003a
Aquatic	
Renal and olfactory system damage, endocrine disruption, behavioral function disorders related to survival and reproduction	Moore and Waring 1998, Moore and Lower 2001
Alteration to microbial community structure, reduced populations	Perez et al 2007, Thom et al 2003
Increased sensitivity to select pesticides after long-term exposure	Pennington and Scott 2001

Endocrine disruptors received attention in 2006 with the discovery of male fish bearing immature oocytes in the Potomac River (MPN 2009). In 2009, EPA announced an initiative to evaluate 67 pesticides as potential endocrine disruptors (MPN 2009). Although the toxic effects of pesticides have been demonstrated at low levels (Odenkirchen and Eisler 1988; Cebrian et al. 1992; Fernandez-Casalderry et al. 1992 as cited in Liu et al. 2001, MPN 2009), there are several considerations that may amplify their toxicity. For example, there are limited research and data on the effects of chronic, long-term exposure, the additive and synergistic effects of exposure to multiple pesticides, and exposure to degradation by-products (Gilliom 2006, Ferrari et al. 1997; Denver and Ator 2007; MPN 2009). In addition, because they are persistent compounds, they bioaccumulate through the food chain and adverse effects magnify (MPN 2009). Degradation products of pesticides are often found in greater concentrations than the parent compound yet they are often not tested for nor regulated (Denver and Ator 2007; MPN 2009). Depending on the characteristics of the pesticide (e.g., mobility, degradation pathways) and the water (e.g., pH, salinity, metals concentration), pesticides can persist in groundwater systems for decades and surface waters for months (Liu et al. 2001; Denver and Ator 2007). The rate of degradation can be highly variable as demonstrated in a study on the hydrolosis of chlorpyrifos, an organophosphorus insecticide, in which rates of degradation varied from 24 to 126 days between the Patuxent and Susquehanna Rivers, respectively (Liu et al. 2001).

3.2. Application Rates and Usage

Pesticides have been detected throughout the waters of the CB and its tributaries (Gilliom et al. 2006; Foster and Lippa 1996; Lehotay et al. 1998; Liu et al. 2002 as cited in MPN 2009), and in its wildlife (Zappia 1996 and Ator 2008 as cited in MPN 2009). Water quality data on pesticides are available for portions of the CB watershed such as the Delmarva Peninsula and the Lower Susquehanna, Potomac and Delware River watersheds which were part of the National Water Quality Assessment (NAWQA) program (USGS 2010). With respect to urban pesticides, researchers for the NAWQA program found that insecticides such as diazinon, carbaryl and chlorphyrifos and the herbicide prometon are more common in urban streams of the Susquehanna River Basin and the Delmarva Peninsula (Denver and Ator 2007). In addition, following a phaseout of diazinon, concentrations of this insecticide decreased by 39% between 1998 and 2004 in an urban stream near Washington, D.C. (Phillips et al. 2007).

Schueler (2001) estimated pesticide application rates on turf in the CB watershed at six pounds per acre per year (lb/ac/yr)[2]. Schueler (2000 as cited in EPA 2010) estimated pesticide application rates on home lawns at 7.5 lb/ac/yr and on golf courses between 37.3 and 45.1 lb/ac/yr. MPN (2009) used national statistics of per capita pesticide use to estimate an annual home and garden use of approximately 6.5 million pounds of pesticide in the CB watershed.

There are significant initiatives in the CB to regulate the use, sale, storage and disposal of non-agricultural use of pesticides, especially in Maryland (Brown et al. 2000). Under the Maryland Pesticide Applicators Law, issued by the MDA, licenses are required for any business providing pest control services, consultations or investigations, any public agency whose employees apply pesticides, or any farmer or nurseryman that intends to use pesticides for the purposes of agricultural production (Brown et al. 2000).These entities are also required to maintain records with details such as the type of pest, acreage sprayed, and the name, concentration, and total amount of pesticide applied. The law also stipulates that public schools must develop and implement an Integrated Pest Management (IPM) system that is approved by the MDA. IPM programs must provide notification of each pesticide used on the school grounds, a 24-hour

[2] We are waiting for the full reference from T. Schueler for details on how this value was estimated.

warning before pesticides are applied, and information on the location of the pesticide application (Brown et al. 2000). As an additional resource, the MDA also maintains a searchable database that provides information on the pesticide name, active ingredient, licensed applicators, licensed dealers, manufacturers, pest name and application location; however, this covers all types of land use applications.

In Harrisburg, Pennsylvania, a pilot-project was conducted to reduce the purchase and use of pesticides using public education programs such as radio and television announcements, training sessions for retail employees, and informational postcards (McKenzie-Mohr & Associates 2007). A short-term decrease of 25-50% in pesticide sales was observed (McKenzie-Mohr & Associates 2007).

At the national-level, approximately 20 percent of pesticide use is not agricultural (MPN 2009). These uses include household use (e.g., weed and insect killers, soaps, cleaners) and runoff from turf areas such as lawns, gardens, golf courses, rights-of-way and landscaping (MPN 2009, NOAA 2005 as cited in MPN 2009). The spatial and temporal distribution of pesticides follows its pattern of use as it is detected in predominantly agricultural and urban land uses with low concentrations year-round and highest concentrations during active application in spring and fall (Ferrari et al. 1997). Variations in concentrations can range by more than four orders of magnitude (Ferrari et al. 1997). Urban land uses tend to have highest concentrations of insecticides in comparison to agricultural land uses which have highest concentrations of herbicides (Ferrari et al. 1997). The types of pesticides used overlap by 20 percent between the top 50 agricultural and the top 50 urban pesticides (Larson et al. 1997 as cited in Ferrari et al 1997) but these trends may be changing. For example, metolachor was historically used primarily in agriculture; however, lawn, turf, rights-of-way, and landscaping application of metolachlor is now common (USEPA 1995 as cited in Debrewer et al. 2005).

National statistics of total pesticide industry sales and usage, coupled with US Census data, have been utilized to approximate household use of pesticides and total amount of active ingredient used in various sectors of industry (Kiely et al. 2004). These data are available and may be useful in scaling estimates of pesticide use to the CB watershed.

4. Impact and Extent of Stormwater Runoff from Linear Development on the Surface Waters of the US

4.1. Impact

"Linear development" is most often used to refer to the construction of roadways and rights-of-way. Rights-of-way (ROWs) include land for gas and water pipelines, sewage and stormwater pipes, and electric, telephone and other transmission lines. In the literature search, we focused on the impacts of ROW-related development. We searched over 40 different terms or combinations of terms but did not find studies specifically documenting the impact of stormwater runoff from ROWs; however, we did find environmental impact statements (EIS) that include the consideration of the impact of proposed linear developments such as transmission lines on the environment including water resources. The Public Service Commission (PSC) of Wisconsin (PSC 2009) provides guidance on assessing and mitigating impacts from the construction of electric transmission lines and facilities; however, the guidance is general and focused on mitigating impacts with respect to crossing waterways. We reviewed three EISs related to transmission lines; and while they all included consideration of short and long-term impacts to surface waters, none made reference to quantitative analyses (Tennessee Valley Authority 2005; State of California Public Utilities Commission 2006; Bureau of Land Management 2010). In EISs concerning larger development, linear development received exemptions in the Highland development in New Jersey where all new major Highlands development is prohibited within a Highlands open water and its adjacent 300-foot buffer except for linear development, which is permitted provided that there is no feasible alternative for the linear development outside the Highlands open water or Highlands open water buffer (NJSA 2005).

More information is available specific to oil and gas line construction due to the regulatory challenges since the passage of the 1987 Water Quality Act (WQA) (section 402(p) of the Clean Water Act) (USEPA 2006).The WQA exempted oil and gas industry from a NPDES permit for uncontaminated discharges; however, EPA did not interpret stormwater runoff to be exempt. Before the Phase II regulations regarding stormwater went into effect, the regulation was challenged by the oil and gas industry based on the economic burden of compliance and EPA deferred the requirements until 2006 for this industry. Before EPA proposed an action, the Energy Policy Act of 2005 defined the exemption of the oil and gas industry as encompassing all activities, thereby entirely exempting the industry (USEPA, 2006).

The EPA has since funded a study to investigate the surface water impacts of gas well sites (Banks and Wachal 2007). However, the study focused on three gas well sites where pad construction and drilling were occurring which are activities comparable to activities regulated under active construction stormwater regulations rather than post-construction stormwater regulations[3].

4.2. Extent of Linear Development in the US

There were approximately 1.69 million miles of oil and gas pipelines in the US in 2007 which was an increase of 12 percent from 1997 (BTS 2010). According to the American Road and Transportation Builders Association (ARTBA) (2010) there are almost 140,000 miles of railroad track (see *Table 3* for breakdown by type of railroad).

Table 3. Miles of Railroad Track

Type of Railroad	Miles
Class 1 freight railroads	95,664
Regional freight railroads	15,388
Local freight railroads	28,197
Total	***139,249***

Amtrak operates 23,000 miles of passenger rail service in the U.S., much of it over track owned by the freight railroads (ARTBA 2010). Beyond these statistics, no additional data were located on the extent of non-roadway related, linear development in the US.

[3] The study found significant impacts from sediment loadings as well as high concentrations of other pollutants in gas well site runoff including total dissolved solids, metals, hardness, alkalinity, and others.

5. Impact and Extent of Stormwater Runoff from Unpaved Roads on Surface Waters of the U.S.

5.1. Impact

The impacts of stormwater runoff specifically from non-forestry related unpaved road surfaces are not well documented. The majority of studies are focused exclusively on forestry related roads (Elliot et al. 1997; Rhee et al. 2004). However, impacts and best management practices (BMPs) described in these studies may be transferrable to unpaved roads in rural or low-density urban settings[4]. In addition, some forestry-related roads may be transferred for recreational or other uses (Welsh 2008[5]). Unpaved roads have compacted soils which lead to decreased infiltration rates and greater runoff as well as bare soils which lead to high sediment loads in runoff. These factors can lead to the ecological impairment of aquatic biota (Elliot et al. 1998, Rhee et al. 2004, Welsh 2008), alterations in channel and reservoir hydrology (Elliot et al. 1998), drinking water contamination (Massachusetts Department of Environmental Protection (MA DEP) 2001), and excessive nutrient inputs (MA DEP 2001, Scheetz and Bloser 2009). Changes in channel substrate and morphology, and increased turbidity associated with unpaved road erosion have been documented to impair salmonid spawning and feeding habitats (Elliot et al. 1998, Coe 2006). Furthermore, sediment from unpaved road runoff can alter the peak discharges of basins and compromise the integrity of reservoirs and bridges (Elliot et al. 1998).

While direct evidence of non-forestry related, unpaved roads are not found in the literature, indirect evidence and acceptance of the impact of rural and suburban unpaved roads are seen in state manuals of stormwater management BMPs (MA DEP 2001, Pennsylvania Department of Environmental Protection (PA DEP) 2005). While these manuals specify management practices, they provide limited background on the impact of dirt roads and justification for requiring BMPs. For example, the MA DEP (2001) summarizes in four sentences and without references that unpaved roads “by the nature of their topography and design can, if not properly managed, contribute heavily to water quality problems.” In Pennsylvania (PA), The PA Conservation District’s Dirt & Gravel Road Pollution Prevention Program was formed in 1997 to “fund environmentally sound maintenance of unpaved roadways that have been identified as sources of dust and sediment pollution (PA DEP 2005).” The PA DEP (2005) also refers to the analysis of data from over 17,000 miles of unpaved roads that resulted in over 11,000 verified pollution sites. While runoff from unpaved roads is not the major source of pollution in streams in PA, the close proximity of rural roads to high quality streams is common, and these roads often run parallel to streams and discharge directly into them (PA DEP 2005).

5.2. Extent of Unpaved Roads and Rates of Sedimentation in Selected Studies

The US Department of Transportation Federal Highway Administration (FHA) (2004) estimates that the 1.3 million miles of unpaved local roads constitute 34.9% of the total mileage of US roads in 2003. Skorseth and Selim (2000) cite an estimate of 1.6 million miles of unpaved roads, accounting for 53% of all roads in the U.S. According to the FHA (2004), annual data suggest

[4] For example, Elliot et al. (1998) found that runoff decreased by 83% and sediment yields decreased by 81% when a 60 meter (m) long, 4 m wide dirt road in Idaho was covered with gravel.
[5] The author makes note that these roads were previously used for mining, and timber harvesting and grazing, but currently are only used for recreation and development.

that the total mileage of unpaved roads has slowly been decreasing since 1960. One estimate for the rate of erosion from unpaved roads was given by Coe (2006) who calculated that ungraded, unpaved public roads contribute an annual average of 0.07 pounds of sediment per square feet in the Sierra Nevada[6].

The Center for Dirt and Gravel Road Studies at Pennsylvania State University (the Center) has conducted research and outreach programs to better understand unpaved road runoff to the CB (Scheetz and Bloser 2008). In a report for the Chesapeake Bay Commission, the Center quantified sediment reductions from five environmentally sensitive maintenance practices (ESMPs) on unpaved public and private roads draining forested, pasture, and low-residential lands (Scheetz and Bloser 2008). The ESMPs included adding a driving surface aggregate, raising the profile of the road, grade breaks, additional drainage outlets, and berm removal. Of the five practices, the addition of driving surface aggregate was the most effective at reducing long-term sediment generation (90% over one year) and preserved flow pathways (Scheetz and Bloser, 2008). Average erosion rates calculated from simulated rainfall events for all five roads before the implementation of ESMPs was 5.6 lbs per 100 feet of road (Scheetz and Bloser, 2008). Considering 20,000 miles of unpaved roads in PA[7] with approximately 11,400 miles lying within the CB, the average storm event releases approximately 1,685 tons of sediment to the CB (Scheetz and Bloser 2008). In addition to their research, the Center advocates the use of ESMPs through outreach programs including landowner interactions, classroom trainings and project brochures (Scheetz and Bloser 2008).

[6] Note that Coe (2006) focused mainly on forestry-related roads.

[7] Local Municipalities and state agencies have jurisdiction of over 90% of dirt and gravel roads in Pennsylvania (PA DEP 2005)

6. References

Ascherio, A, et al. (2006). Pesticide exposure and risk for Parkinson’s disease. Annals of Neurology.

ARTBA. (2010). "FAQs: How many miles of roads are there in the U.S.?", July 2010, from http://www.artba.org/about/faqs-transportation--general-public/faqs/.

Ator, SW, et al. (2004). Hydrologic and Geochemical Controls on Pesticide and Nutrient Transport to Two Streams on the Delmarva Peninsula. Scientific Investigations Report 2004-5051. US Geological Survey,.

Banks, K and Wachal, D. (2007). United States Environmental Protection Agency Final Report for Catalog of Federal Domestic Assistance Grant Assistance Number 66.463 Water Quality Cooperative Agreement for Project Entitled “Demonstrating the Impacts of Oil and Gas Exploration on Water Quality and How to Minimize these Impacts Through Targeted Monitoring Activities and Local Ordinances". ID No. CP-83207101-1.

BLM. (2010). North Steens Transmission Line EIS: Section 3 Affected Environment, Environmental Consequences, and Mitigation.

Boesch, DF, et al. (2001). Chesapeake Bay Eutrophication: Scientific Understanding, Ecosystem Restoration, and Challenges for Agriculture. Journal of Environmental Quality 30: 300-320.

Brown, A, et al. (2000). Leaflet No. 35: Synopsis of the Maryland Pesticide Applicators Law and Regulations. UoMC Extension.

BTS. (2010). "Table 1-10: U.S. Oil and Gas Pipeline Mileage". accessed July 2010, from http://www.bts.gov/publications/national_transportation_statistics/html/table_01_10.html .

Buckley, J, et al. (1994). Epidemiological characteristics of Childhood Acute Lymphocytic Leukemia. Leukemia 8(5): 856-864.

CAPUC. (2006). Antelope-Pardee 500-kV Transmission Project C.8 Hydrology and Water Quality.

Cavieres, MF, et al. (2002). Developmental toxicity of a commercial herbicide mixture in mice: Effects on embryo implantation and litter size. Environmental Health Perspectives 110: 1081-1085.

CBPO. (2009). State of the Chesapeake Bay Program 2009, Summary Report to the Chesapeake Executive Council. from http://archive.chesapeakebay.net/pressrelease/EC_2009_stateofprogram.pdf.

CBSMI. (2005). Chesapeake Bay Social Marking Initiative 2004-2005 Final Report. from http://www.epa.gov/nps/toolbox/surveys/Final_Chesapeake_Club_Report.pdf.

Cebrian, C, et al. (1992). Acute toxicity and oxygen consumption in the gills of Procambarus Clarkii in relation to Chlorpyrifos exposure. Bulletin of Environmental Contamination and Toxicology 49: 145-149.

Chou et al. (2008). as cited in the Maryland Pesticide Network White Paper (full citation forthcoming). Journal of Biological Chemistry.

Claggelt, P. (2007). Chapter 2: Human Population Growth and Land-Use Change. Circular 1316: Synthesis of U.S. Geological Survey Science for the Chesapeake Bay Ecosystem and Implications for Environmental Management. SW Phillips. US Geological Survey, Reston, VA.

Claggelt, P. (2010). personal communication: Chesapeake Bay Program Office Model Information, received by V Zoltay.

Coe, DBR. (2006). Sediment production and delivery from forest roads in the Sierra Nevada, California. Department of Forest, Rangeland, and Watershed Stewardship. Colorado State University, Fort Collins, Colorado. Master of Science: 117.

Davis, J, et al. (1993). Family Pesticide Use and Childhood Brain Cancer. Archives of Environmental Contamination and Toxicology 24(87-92).

Debrewer, LM, et al. (2005). Factors affecting spatial and temporal variability in nutrient and pesticide concentrations in the surficial aquifer on the Delmarva Peninsula. 2005–5257. U.S. Geological Survey, USDot Interior.

Denver, JM and Ator, SW. (2007). Chapter 8: The Occurrence of Pesticides in the Bay Watershed. Circular 1316: Synthesis of U.S. Geological Survey Science for the Chesapeake Bay Ecosystem and Implications for Environmental Management. SW Phillips. US Geological Survey, Reston, VA: 71.

Elliot, WJ, et al. (1997). Predicting the impacts of forest roads on the environment. Third Brazilian Harvesting and Transportation Symposium, Vitoria, ES, Brazil.

Eriksson et al. (1998). as cited in the Maryland Pesticide Network White Paper (full citation forthcoming).

Fernandez-Casalderry, A, et al. (1992). Endosulfan and diazinon toxicity to the freshwater rotifer Brachionus Calyciflorus. Journal of Environmental Science and Health B27: 155-164.

Ferrari, MJ, et al. (1997). Pesticides in Surface Water of the Mid-Atlantic Region. WRIR 97-4280. US Geological Survey, UDot Interiorfrom http://md.water.usgs.gov/publications/wrir-97-4280/wrir_97_4280_html.html.

FHA. (2004). "1996-2003: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics." Washington, DC: Annual issues: table HM-12, from www.fhwa.dot.gov/policy/ohpi.

Fisher, TR, et al. (2006). Cultural eutrophication in the Choptank and Patuxent estuaries of Chesapeake Bay. Limnology and Oceanography 51(1, part 2): 435-447.

Foster, G and Lippa, K. (1996). Fluvial Loadings of Selected Organonitrogen and Organophosphorus Pesticides to Chesapeake Bay. Journal of Agricultural and Food Chemistry 44(8): 2447-2454.

Fuhrer, GJ, et al. (1999). The Quality of Our Nation's Waters:Nutrients and Pesticides. Circular 1225. US Geological Survey, UDot Interior,Reston, VA. from http://pubs.usgs.gov/circ/circ1225/pdf/index.html.

Gill, S, et al. (2001). Fertilizer Recommendations for Landscape Trees and Shrubs (For Professional Grounds and Landscape Contractors). Fact Sheet 789. University of Maryland Cooperative Extension,.

Gilliom, RJ. (2006). Pesticides in the Nation's Streams and Ground Water,1992–2001—A Summary. Fact Sheet 2006–3028. US Geological Survey,.

Gold, E, et al. (1979). Risk Factors for Brain Tumors in Children. American Journal of Epidemiology 109(3): 309-319.

Hayes, T, et al. (2006). Pesticide mixtures, endocrine disruption, and amphibian declines: are we underestimating the impact? Environ Health Perspectives 114(Supplement 1): 40-50.

Kemp, WM, et al. (2005). Eutrophication of Chesapeake Bay: historical trends and ecological interactions. Marine Ecology Progress Series 303: 1-29.

Kiely, T, et al. (2004). Pesticides Industry Sales and Usage: 2000 and 2001 Market Estimates. U.S. Environmental Protection Agency,Washington, D.C.

Larson, SJ, et al. (1997). Pesticides in surface waters — Distribution, trends, and governing factors. Ann Arbor Press: 373.

Lassiter et al. (2008). as cited in the Maryland Pesticide Network White Paper (full citation forthcoming). Environmental Health Perspectives.

Law, NL, et al. (2004). Nitrogen Input from Residential Lawn Care Practices in Suburban Watersheds in Baltimore County, MD. Journal of Environmental Planning and Management 47(5): 737-755.

Lehotay, SJ, et al. (1998). Agricultural pesticide residues in oysters and water from two Chesapeake Bay tributaries. Marine Pollution Bulletin 37: 32-44.

Leiss, J and Savitz, D. (1995). Home Pesticide Use and Childhood Cancer: A Case-Control Study. American Journal of Public Health 85(249-252).
Lindsey, BD, et al. (2003). Residence Times and Nitrate Transport in Ground Water Discharging to Streams in the Chesapeake Bay Watershed. 2003-4035. US Geological Survey, UDot Interior,Reston, VA.
Liu, B, et al. (2001). Hydrolysis of chlorpyrifos in natural waters of the Chesapeake Bay. Chemosphere 44: 1315-1323.
Liu, B, et al. (2002). Herbicide and Insecticide Loadings from the Susquehanna River to the Northern Chesapeake Bay. Journal of Agricultural and Food Chemistry 50: 4385-4392.
Lowengart et. al. (1995). as cited in the Maryland Pesticide Network White Paper (full citation forthcoming).
Lowengart, R, et al. (1987). Childhood leukemia and parents'occupation and home exposures. Journal of the National Cancer Institute 79: 39-46.
MA DEP. (2001). The Massachussetts Unpaved Roads BMP Manual: A Guidebook on How to Improve Water Quality While Addressing Common Problems. Project 98-06/319. U.S. Environmental Protection Agency.
Magnien, R, et al., Eds. (1995). The state of the Chesapeake 1995. US Environmental Protection Agency, Annapolis, MD.
McKenzie-Mohr & Associates. (2007). Reducing Residential Pesticide Use: White Paper. Southwest Florida Water Management District, from http://www.swfwmd.state.fl.us/files/database/social_research/Pesticides_Final_Report.pdf.
MDA. (2010). "Listing of Fertilizers-Pesticides Registered". from http://www.mda.state.md.us/pdf/state_chemist/fert_pest.pdf.
MDAC. (2009). Title 6: Subtitle 2: 6-222. Low phosphorus fertilizer. from http://www.michie.com/maryland/lpext.dll?f=templates&fn=main-h.htm&2.0.
Montgomery County. (2003). The Use of Fertilizers in the State of Maryland.
Moore, A and Lower, N. (2001). The impact of two pesticides on olfactory-mediated endocrine function in mature male Atlantic salmon (Salmo salar L.) parr. Comparative Biochemistry and Physiology Part B 129: 269-276.
Moore, A and Waring, C. (1998). Mechanistic effects of atriazine pesticide on reproductive endocrine function in mature male Atlantic salmon (Salmo salar L.) parr. Pesticide Biochemistry and Physiology 62: 41-50.
MPN. (2009). Pesticides and the Maryland Chesapeake Bay Watershed: White Paper.Annapolis, MD.
NJSA. (2005). Highlands Water Protection and Planning Act Special Adopted New Rules: N.J.A.C. 7:38 DEP Docket Number: 16-05-05/481. from http://www.state.nj.us/dep//rules/adoptions/njac7_38_20050509.pdf.
NOAA. (2005). Pollutants from Nonpoint Sources: Pesticides and Toxic Chemicals. National Ocean Service, from www.oceanservice.noaa.gov/education/kits/pollution/012chemicals.html.
Odenkirchen, E and Eisler, R. (1988). Chlorpyrifos hazards to fish, wildlife, and invertebrates: a synoptic review Biological Report 85, 1.13. US Fish and Wildlife Service
PA DEP. (2005). Pennsylvania Stormwater Best Management Practices Manual: Section 8 Special Stormwater Management for Highways and Roads.
Pennington, P and Scott, G. (2001). Toxicity of atrazine to the estuarine phytoplankter Pavlova sp. (Prymnesiophyceae): increased sensitivity after long-term, low-level population exposure. Environmental Toxicology and Chemistry 20(1): 2237-2242.
Pérez, G, et al. (2007). Effects of the herbicide Roundup on freshwater microbial communities: a mesocosm study. Ecological Applications 17(8): 2310-2322.

Phillips, SW, et al. (2007). Temporal Changes in Surface-Water Insecticide Concentrations after the Phaseout of Diazinon and Chlorpyrifos. Environmental Science and Technology 41(12): 4246-4251.

Porter, WP, et al. (1999). Endocrine, immune and behavioral effects of aldicarb (carbamate), atrazine (triazine) and nitrate (fertilizer) mixtures at ground water concentrations. Toxicology and Industrial Health 15(1-2): 133-150.

PSC. (2009). Environmental Impacts of Transmission Lines. Public Service Commission of Wisconsin,, from http://www.psc.wi.gov.

Reeves, J. (1982). Household Insecticide-Associated Blood Dyscrasias in Children. American Journal of Pediatric Hematology/Oncology 4: 438-439.

Rhee, H, et al. (2004). Modeling erosion from unpaved forest roads at various levels of geometric detail using the WEPP model. American Society of Agricultural Engineers 47(3): 961-968.

Ricigliano, D. (2004). Fertilizing Facts for Home Lawns. HG 103. University of Maryland Cooperative Extension,.

Roberts, E, et al. (2007). Maternal Residence Near Agricultural Pesticide Applications and Autism Spectrum Disorders among Children in the California Central Valley. Environ Health Perspectives 115(10): 1482-1489.

Ruddy, BC. (2006). County-Level Estimates of Nutrient Inputs to the Land Surface of the Conterminous United States, 1982–2001. 2006-5012. U.S. Geological Survey, UDot Interior,Reston, VA.

Scheetz, BE and Bloser, SM. (2008). Environmentally Sensitive Maintenance Practices for Unpaved Roads: Sediment Reduction Study Final Report. Center for Dirt and Gravel Road Studies.

Scheetz, BE and Bloser, SM. (2009). Environmentally Sensitive Maintenance on Agricultural Roads to Reduce Nutrient and Sediment Pollution in the Kishacoquillas Watershed. The Pennsylvania State University, USDoACIG Program.

Schueler, T. (2001). The grass crop in the Chesapeake Bay watershed. Envirocast: Weather and Watershed Newsletter. National Environmental Education and Training Foundation, Washington, DC.

Schueler, T. (2010). The Clipping Point: Turf Cover Estimates for the Chesapeake Bay Watershed and Management Implications. Chesapeake Stormwater Network Technical Bulletin No. 8.

Schueler, T and Holland, H, Eds. (2000). The Peculiarities of Perviousness: Article 129. The Practice of Watershed Protection. Center for Watershed Protection (CWP), Ellicott City, MD.

Skorseth, K and Salim, AA. (2000). Gravel Roads: Maintenance and Design Manual. US Department of Transportation.

Swann, C. (1999). A Survey of Resident Nutrient Behavior in the Chesapeake Bay Watershed. Center for Watershed Protection, CR Consortium,Ellicott City, MD.

Thom, NS, et al. (1975). The Breakdown of Synthetic Organic Compounds in Biological Processes [and Discussion]. Proceedings of the Royal Society of London. Series B, Biological Sciences.

TVA. (2005). 500-kV Transmission Line in Middle Tennessee.

USEPA. (1995). R.E.D. Facts: Metolachlor. EPA-738-F-95-007. Office of Prevention, Pesticides and Toxic Substances (7508W).

USEPA. (2003). Food Quality Protection Act (FQPA) of 1996. from http://www.thecre.com/fedlaw/.

USEPA. (2006). Final Rule: Amendments to the Storm Water Regulations for Discharges Associated with Oil and Gas Construction Activities.

USEPA. (2010a). Chesapeake Bay Phase 5 Community Watershed Model.Annapolis, MD. from http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

USEPA. (2010b). Guidance for Federal Land Management in the Chesapeake Bay Watershed. EPA841-R-10-002.

USGS. (2010). Complete Listing of NAWQA's Study Units and Summary Reports.

Welsh, MJ. (2008). Sediment production and delivery from forest roads and off-highway vehicle trails in the Upper South Platte River watershed, Colorado. Department of Forest, Rangeland, and Watershed Stewardship. Colorado State University, Fort Collins, Colorado: 237.

Wible, CJ. (2010). "Comment attachment submitted by Chris J. Wible, Director, Environmental Stewardship, The Scotts Miracle-Gro Company. Comment on Proposed Rule: Executive Order 13508 Chesapeake Bay Protection and Restoration Section 502 Guidance: Federal Land Management in the Chesapeake Bay Watershed Docket ID: EPA-HQ-OW-2010-0164."   Retrieved April 29, 2010, from http://www.regulations.gov/search/Regs/home.html#documentDetail?R=0900006480adebe3.

Zahm Hoar, S and Ward, M. (1998). Pesticides and childhood cancer. Environmental Health Perspectives 106(Supplement 3).

Zappia, H. (1996). Chlordane, DDT, PCB’s, and other selected organic compounds in asiatic clams and yellow bullhead in the Potomac River Basin, 1992. Geological Survey Water-Resources Investigations Report 96-4210.